

CLAIMS

1. A method of controlling combustion of a fuel within a combustion chamber of internal combustion engine, said method comprising,
 - a. during a cycle of said engine:
 - i. introducing a charge into said combustion chamber,
 - ii. compressing said charge within said combustion chamber,
 - iii. introducing said fuel into said combustion chamber,
 - iv. burning said fuel within said combustion chamber to drive a piston disposed within said combustion chamber,
 - b. delivering an accelerometer data set to a controller, said accelerometer data set collected during at least two cycles of said engine,
 - c. processing said accelerometer data set to generate a processed data set indicative of a heat release rate over said at least two cycles,
 - d. estimating from said processed data set, an SOC error using a pre-determined target start of combustion for said fuel,
 - e. if the magnitude of said SOC error is greater than 0, adjusting a start of combustion lever for at least one subsequent cycle of said engine to drive a corrected start of combustion during said at least one subsequent cycle towards said pre-determined target start of combustion.
2. The method of claim 1 wherein said lever is at least one of:
 - a. glow plug temperature,
 - b. spark plug timing,
 - c. pilot fuel quantity,
 - d. pilot fuel injection timing,
 - e. intake manifold temperature,
 - f. intake manifold pressure,
 - g. exhaust gas intake charge concentration,
 - h. pilot fuel injection duration, and
 - i. equivalence ratio of said fuel.

3. The method of claim 1 wherein said SOC error is determined from a comparison of an estimated start of combustion of said fuel determined from said processed data set and said pre-determined target start of combustion.

4. The method of claim 1 wherein said controller adjusts said start of combustion lever.

5. The method of claim 1 wherein a second controller adjusts said start of combustion lever.

6. The method of claim 1 wherein said accelerometer data set is collected from at least 10 consecutive cycles of said engine.

7. The method of claim 1 wherein said accelerometer data set is collected from between 5 and 15 consecutive cycles of said engine.

8. The method of claim 1 wherein said pre-determined start of combustion is based on at least one of engine speed and boost pressure.

9. The method of claim 1 wherein a cepstral filter is applied to said accelerometer data set to provide said processed data set.

10. The method of claim 3 wherein said estimated start of combustion is determined using a peak value of said processed data, a crank angle associated with said peak value of said processed data and a boost pressure associated with said charge over said at least two cycles.

11. The method of claim 10 wherein said estimated start of combustion is determined using the following relationship:

$$SOC = a_1 + (a_2 + a_3 x(\theta_p)) \times x(\theta_p) + (a_4 + a_5 \theta_p) \times \theta_p + (a_6 + (a_7 + a_8 x(\theta_p)) \times x(\theta_p) + (a_9 + a_{10} \theta_p) \times \theta_p) \times P$$

where a_1, \dots, a_{10} are constants from said processed data set, $x(\theta_p)$ is said peak value, θ_p is said peak value crank angle, and P is said boost pressure.

12. The method of claim 3 wherein said estimated start of combustion is determined using a slope value of said processed data determined from an associated crank angle for said slope value earlier than a peak crank angle.

13. The method of claim 1 further comprising selecting from said accelerometer data set a knock measurement, said knock measurement used to control rate of combustion in said subsequent cycle of said engine.

14. The method of claim 1 further comprising selecting from said accelerometer data set a misfire measurement, said misfire measurement used to control combustion in said subsequent cycle of said engine.

15. A method of determining combustion quality within a combustion chamber of an operating internal combustion engine, said method comprising:

a. during a cycles of said engine, generating an accelerometer data set from accelerometer measurements provided by an accelerometer positioned on said engine capable of measuring data indicative of combustion behavior within said combustion chamber;

b. processing said accelerometer data set to reconstruct a processed data set indicative of heat release rate within said combustion chamber during said cycle of said engine;

c. comparing properties of said processed data set with properties of a predetermined desired data set to provide an indication of said combustion quality.

16. The method of claim 15 further comprising calculating a transfer function appropriate for reconstructing said processed data set from said² accelerometer data set.

17. The method of claim 15 wherein a cepstral filter is applied to said accelerometer data set data set to generate said processed data set.

18. The method of claim 15 wherein a peak value from said processed data is compared to a peak value from said predetermined desired data set to provide said indication of said combustion quality.

19. A method of estimating start of combustion within a combustion chamber of an internal combustion engine,

- a. during a cycle of said engine:
 - i. introducing a charge into said combustion chamber,
 - ii. compressing said charge within said combustion chamber,
 - iii. introducing a fuel into said combustion chamber,
 - iv. burning said fuel within said combustion chamber to drive a piston disposed within said combustion chamber,
 - v. determining a data set indicative of a physical condition within said combustion chamber during said cycle,
- b. accumulating at least two data sets from corresponding cycles of said engine;
- c. processing said at least two data sets to generate processed data sets indicative of a heat release rate over said corresponding cycles of said engine, wherein a cepstral filter is applied to said at least two data sets to generate said processed data sets,
- d. estimating said start of combustion for said corresponding cycles of said engine from a predetermined relationship that is a function of selected properties of said processed data sets.

20. The method of claim 19 wherein between 5 and 15 data sets are used to generate said processed data sets.

21. The method of claim 19 wherein fewer than 20 data sets are used to generate said processed data sets.

22. The method of claim 19 wherein said at least two data sets are accumulated from consecutive cycles of said engine.

23. The method of claim 19 wherein said data set is collected from at least one of an accelerometer, an optical sensor, a strain gauge and a pressure sensor.

24. The method of claim 19 wherein an averaging filter is applied to said at least two data sets prior to applying said cepstral filter.

25. The method of claim 19 wherein said selected properties comprise at least one of a peak value, a peak value crank angle, a crank angle curve width at a pre-determined fraction of said peak value, a slope of said processed data at a rising crank angle found prior to said peak value, and a ratio of said peak value and said width.

26. The method of claim 25 wherein said predetermined relationship is:

$$SOC = a_1 + (a_2 + a_3 x(\theta_p)) \times x(\theta_p) + (a_4 + a_5 \theta_p) \times \theta_p + (a_6 + (a_7 + a_8 x(\theta_p)) \times x(\theta_p) + (a_9 + a_{10} \theta_p) \times \theta_p) \times P$$

where a_1, \dots, a_{10} are constants from said processed data set, $x(\theta_p)$ is said peak value, θ_p , is said peak value crank angle, and P is a boost pressure associated with said charge over said corresponding cycles.